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FOOD HABITS, WEIGHT DYNAMICS, AND FAT CONTENT OF BOBWHITES IN RELATION TO FOOD PLANTINGS IN KANSAS

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FOOD HABITS, WEIGHT DYNAMICS, AND FAT CONTENT OF BOBWHITES IN RELATION TO FOOD PLANTINGS IN KANSAS[1]

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Abstract: During a 6-year evaluation of plantings designed to provide additional winter food for bobwhite quail (*Colinus virginianus*) on the Fort Riley Military Reservation in Kansas, quail were killed to provide data on food habits, body weight dynamics, and fat content of carcasses. Crop contents of 591 quail were analyzed to determine food habits, 308 quail were weighed to detect seasonal changes in body weights, and 41 quail carcasses were analyzed for ether extractable fat content. Bobwhites within 800 m of food plots used the plots as feeding areas during winter and early spring months. Compared with birds killed farther than 900 m from a food plot during the winter and early spring, quail killed within 800 m of a food plot during the same period had more food in their crops, maintained higher body weights, and had more fat in their carcasses.

With the enactment of the Federal Aid to States in Wildlife Restoration Act (commonly known as the Pittman–Robertson Act) in 1937, funds for wildlife research and development became available to state fish and game agencies. Following World War II, great sums of money were invested in habitat-improvement programs. Even though improvement of wildlife habitat has been and continues to be an almost universal endeavor of state fish and game agencies, the effectiveness of many of these habitat-improvement programs to produce larger game populations has not been intensively studied. Evaluations of habitat-improvement programs have been concerned primarily with acreage included and gross changes in floral characteristics. Lyon (1959), Tester and Marshall (1962), and Vohs (1959) are among the few who have attempted to relate habitat-improvement programs to changes in faunal as well as floral populations.

In 1959, a wildlife management program was initiated on the Fort Riley Military Reservation in Kansas under Army Regulations 210-221 (Joselyn 1965:219). The wildlife management program had several aspects, including establishment of food plantings as part of a broad habitat-improvement program. In 1961, G. B. Joselyn (conservation and wildlife management officer at the Fort during 1961–62) invited the author to work with personnel in evaluating certain aspects of the habitat-improvement program. This is a report of a 6-year study of responses of bobwhite quail to food plantings on the Reservation.

The interest, efforts, and unlimited cooperation of Fort Riley military personnel,

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STUDY AREA

This research was conducted on the Fort Riley Military Reservation in Riley County, 8 miles southwest of Manhattan, Kansas. The study area, consisting of approximately 31,000 acres, was farm and range land prior to its purchase by the Army in 1941. Lowland areas were used for crop production while the upland area was grazed by beef cattle. All commercial farming operations ceased in 1941. Ruins of old farmsteads and remains of hedgerows are still present.

The Reservation is on the western edge of the Kansas Flint Hills. It is approximately 60 percent prairie uplands, 30 percent lowlands, and 10 percent steep slopes. The native vegetation of the uplands is classed as true prairie (Fish 1953:20) and consists primarily of an herbaceous plant association. Prominent grasses include bluestem (*Andropogon*)[2], wheat grass (*Agropyron*), grama (*Bouteloua*), lovegrass (*Eragrostis*), wildrye (*Elymus*), witchgrass (*Panicum*), bristlegrass (*Setaria*), indiangrass (*Sorghastrum*), and dropseed (*Sporobolus*). Many forbs are present on upland and lowland sites, including ragweed (*Ambrosia*), partridgepea (*Cassia*), lespedeza (*Lespedeza*), sweetclover (*Melilotus*), milkweed (*Asclepias*), hemp (*Cannabis*), goosefoot (*Chenopodium*), croton (*Croton*), sunflower (*Helianthus*), smartweed (*Polygonum*), dock (*Rumex*), and goldenrod (*Solidago*). Trees and other woody plants are common on the slopes and lowland areas and include maple (*Acer*), redbud (*Cercis*), dogwood (*Cornus*), walnut (*Juglans*), redcedar (*Juniperus*), osage orange (*Maclura*), cottonwood (*Populus*), plum (*Prunus*), oak (*Quercus*), sumac (*Rhus*), locust (*Robinia*), willow (*Salix*), and elm (*Ulmus*).

[2] Common and scientific names of plants follow Anderson (1961).

METHODS

Plantings of corn, wheat, and sorghum were established on the Reservation by military personnel. Normally a food plot consisted of a combination of corn and sorghum but sometimes corn, sorghum, and wheat were planted adjacent to each other. Early in the study, food patches were small (0.5–2 acres each) and scattered over the entire Reservation except for a central artillery impact area. During 1965 and 1966, in addition to the many small and isolated food patches, several long narrow plots (up to 2 miles long) of corn and sorghum were established to utilize available large equipment more effectively. Areas producing cultivated grain for wildlife varied from year to year, averaging 98, 146, and 34 acres of corn, sorghum, and wheat, respectively (Table 1). All planted grain was left standing for the entire winter.

Bobwhite quail were collected regularly during November, 1961–April, 1962 and September–April of 1962 through 1967. Sporting firearms were used to kill the quail and bird dogs helped in locating coveys and retrieving cripples. Collecting was normally limited to late afternoon hours and no more than two quail ever were taken from any one covey on the same day. Time and location of kill plus sex and age were recorded for each bird collected. Precise kill locations were determined in the field by using military coordinates on contour maps with a scale of 4 inches per mile. Tip coloration of the greater upper primary feathers (Leopold 1939) and appearance of the seventh greater primary coverts (Haugen 1957) were used as criteria to separate juveniles

Table 1. Approximate acreage producing cultivars on Fort Riley during this study.

Season	Productive Acres			
	Corn	Sorghum	Wheat	Total
1961–62	140	90	15	245
1962–63	95	145	15	255
1963–64	160	85	30	275
1964–65	10	115	25	150
1965–66	155	225	60	440
1966–67	25	215	60	300
Averages	98	146	34	278

from adults. Sex was determined by body plumage characteristics.

Bobwhites were weighed within 3 hours of the time they were killed. Crop contents were removed prior to weighing the bird to the nearest 0.1g.

Food habits were determined by analyzing crop contents. Contents of each quail crop were air dried 2 days in an open petri dish, sorted into homogeneous categories under a magnifying lamp, and identified. Each homogeneous category was placed in a 10-ml graduated cylinder and its volume determined after compacting the material slightly with a wooden dowel. Volumes of each constituent found in the crops were totaled for each month and its percentage of the monthly volumetric total calculated.

Body fat determinations were made on 41 quail carcasses during the 1966–1967 collecting season. The crop of each bird was removed prior to fat analyses. Carcasses were quick-frozen and stored at −20 C until analyzed. Each bird was analyzed individually. While frozen, birds were sawed lengthwise and processed through a Universal No. 3 food chopper (fine cutter). The chopped material was then dried 24 hours at 60 C, again processed through the chopper and thoroughly blended. Moisture-free weight was determined after drying 2-g samples for 5 hours at 110 C under vacuum (28 inches of Hg). Fat was extracted from two 2-g samples of each bird in a Goldfisch extraction apparatus for 16 hours using anhydrous diethyl ether as a solvent. Samples were then redried at 110 C for 5 hours under vacuum and reweighed. Ether-extractable fat was expressed as a percentage of dry tissue weight.

RESULTS AND DISCUSSION

During this 6-year study, 595 bobwhite quail were collected. Crop contents were analyzed for 591 specimens, weights recorded for 368 birds, and body fat determinations made of 41 carcasses. Intestinal tracts of 249 birds were removed and examined for internal helminths.

Of the 595 birds, 480 (80.7 percent) were juveniles and 115 (19.3 percent) adults (Table 2). The number of juveniles per

Table 2. Numbers of adult and juvenile bobwhite quail collected per month during this study.

Month	1961–62		1962–63		1963–64		1964–65		1965–66		1966–67		Totals		J/A
	J	A	J	A	J	A	J	A	J	A	J	A	J	A	
September	*		14	1	10	2	13	2	17	2	14	1	68	8	8.5
October	*		11	1	18	1	14	3	18	2	13	3	74	10	7.4
November	9	1	23	2	22	1	13	4	12	2	13	3	92	13	7.1
December	8	2	19	4	6	0	9	4	12	3	9	3	63	16	3.9
January	5	5	6	1	10	2	10	3	13	3	8	3	52	17	3.1
February	3	1	8	2	7	5	13	3	10	5	7	2	48	18	2.7
March	11	4	4	0	6	4	7	3	13	2	7	2	48	15	3.2
April	3	1	4	1	9	4	6	4	7	3	6	5	35	18	1.9
Totals	39	14	89	12	88	19	85	26	104	20	77	22	480	115	4.2
	53		101		107		111		124		99		595		

* No collections made during September and October, 1961.

Table 3. Numbers of male and female bobwhite quail collected per month during the course of this study.

	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		March		April	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1961–62	*		*		4	6	3	7	7	3	1	3	8	7	1	3
1962–63	6	9	5	7	13	12	10	13	3	4	6	4	2	2	3	2
1963–64	6	6	7	12	11	12	3	3	5	7	6	6	6	4	6	7
1964–65	5	10	7	10	10	7	9	1	10	3	6	10	5	5	4	6
1965–66	8	11	14	6	11	3	7	8	11	5	10	5	9	6	3	7
1966–67	11	4	8	8	9	7	7	5	6	5	3	6	3	6	5	6
Totals	36	40	41	43	58	47	39	40	42	27	32	34	33	30	22	31
Females/Male	1.10		1.05		0.81		1.03		0.64		1.06		0.91		1.41	

* No collections made during September and October, 1961.

adult was 7.5 for 265 birds collected during the September–November period compared with 2.7 juveniles per adult for 251 birds collected during January–April. Such a seasonal shift in the juvenile/adult ratio reflects either an age-related differential mortality or a seasonally-related shift in vulnerability of both age-classes to the collection techniques used. The author favors the former hypothesis (Robel 1965) but no data have been collected to challenge the latter. Males constituted 50.9 percent of the birds collected while females accounted for 49.1 percent (Table 3). Although sex ratios varied from month to month, no seasonal trends were detected in sex ratios of birds collected.

Food Habits

In 555 quail collected during the last 5 hours of daylight (270 min before to 30 min after sunset), average volume of food in each crop was determined for each 1-hour period (Fig. 1). During the fall and early winter period, two peaks were observed in crop contents: one at 211 to 270 min before sunset and the other at 30 min before to 30 min after sunset. In the winter and early spring period (January–April), the average amount of food in each quail crop did not vary appreciably with the time the bird was killed. Birds killed during the September–February period had an average of 6.47 cc of material in their crops compared with only 3.75 cc in the crops of birds collected

Table 4. Monthly volumes of food in crops of 109 adult and 475 juvenile bobwhite quail.

Month	Juveniles		Adults		Pooled	
	N	Vol.[a]	N	Vol.	N	Vol.
September	67	5.57 ± 0.47	11	6.17 ± 0.79	78	5.60 ± 0.41
October	74	6.01 ± 0.50	10	5.78 ± 0.80	84	5.98 ± 0.45
November	92	6.03 ± 0.47	11	9.37 ± 1.80[b]	103	6.39 ± 0.47
December	60	6.25 ± 0.66	18	8.70 ± 1.80	78	6.81 ± 0.67
January	54	8.10 ± 0.59	16	6.58 ± 1.28	70	7.73 ± 0.54
February	49	6.37 ± 0.73	16	6.58 ± 1.42	65	6.42 ± 0.61
March	52	4.03 ± 0.65	11	5.00 ± 1.07	63	4.20 ± 0.50
April	27	2.07 ± 0.43	15	4.87 ± 1.08[c]	42	3.07 ± 0.51

[a] Volume in cubic centimeters ± one standard error of the mean.
[b] Differs significantly ($P \leq 0.10$) from volume in crops of juveniles.
[c] Differs significantly ($P < 0.05$) from volume in crops of juveniles.

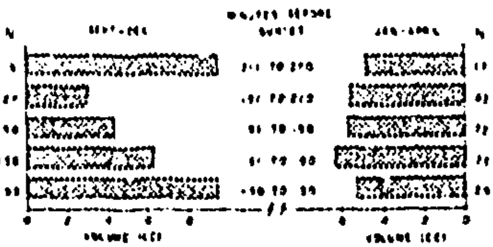

Fig. 1. Time-related changes in volumetric contents of 321 and 234 bobwhite quail crops collected during September–December and January–April periods, respectively.

in March and April. The volume of material in the crops of adult birds collected in November and April was significantly greater ($P < 0.10$ and $P < 0.05$, respectively) than the amount of material contained in crops of juveniles during those months (Table 4).

Twenty items, each constituting 1.0 percent or more of the total volumetric contents of 591 quail crops, accounted for 94.0 percent of the quail diet during this study (Table 5). The item of greatest volume was *sorghum* (18.3 percent) while sunflower seed was the food item with the highest *frequency* (30.9 percent). Grass seeds, mainly *Setaria, Trifolium*, and *Bromus*, contributed 9.7 percent of the diet and occurred in 29.6 percent of the crops. Western ragweed and sumac seeds comprised 7.1 and 6.4 percent of the diet, respectively, and were present in 26.9 and 12.0 percent of the crops, respectively.

Animal matter contributed 7.5 percent of the volume and was found in 27.8 percent of the crops. The 7.5 percent figure for volume of animal matter is minimal since data were not adjusted for shrinkage of desiccated animal tissues. Grasshoppers, crickets, cockroaches, bugs, caterpillars, beetles, and ants were the more common forms of animal matter found in the crops of quail.

The three cultivars, corn, wheat, and sorghum, contributed 25.4 percent of the quail diet during this study. Both corn and sorghum were *much more abundant in the* winter and spring diet of quail than in the fall. *Use of wheat as a food item by quail* was limited (1.7 percent) and no noticeable seasonal differences were apparent in its consumption.

Seeds of sunflower, western ragweed, and grasses were consumed more during the fall and early winter than during the late winter and spring. Conversely, seeds of sumac, osage orange, and black locust constituted more of the spring crop contents than either the fall or winter diet. Debris was more abundant in quail crops from spring collections than during either fall or early winter. Animal matter was most abundant during the fall and spring periods and less abundant in crops collected in winter.

Except for slightly reduced use of cultivated crops, quail in this study had food habits similar to those reported earlier for Kansas bobwhites by Jennings (1941:423) and Robinson (1957:21–23).

Weight Dynamics

The mean weight of 568 quail was 186.23 ± 1.03 g. The monthly mean body weights exhibited seasonal changes, increasing during the September through December period then decreasing through March and stabilizing in April (Table 6). The general curve of body weights (Fig. 2) is similar to results reported by Wickliff (1932), Hamilton (1957), and Robinson (1957:49). Mean weights of juveniles were less than adults for all months except January. Because of the variability in the weights of collected birds and the small number of adults in each monthly sample, only the mean weights of birds collected in November ($P < 0.05$), October ($P < 0.05$), and March ($0.05 < P < 0.10$) showed significant age-related differences. Kabat and Thompson (1963:41)

Table 5. Items constituting 1.0 percent or more of the total volumetric contents of crops from 591 bobwhite quail collected during this study. Tabular data expressed as percentages, percent of volumetric contents over frequency of occurrence during each period.

Item	Sample Size	September	October	November	December	January	February	March	April	Sept.–Apr.
	Number	76	84	100	85	70	61	63	43	591
	Volume (cc)	417.1	303.9	617.5	347.7	541.0	417.2	260.9	130.5	3,091.1
Sorghum *Sorghum vulgare*		11.4/13.8	8.5/21.1	12.1/20.7	17.7/18.8	28.0/35.7	36.1/25.0	10.7/11.1	28.7/18.6	18.3/21.0
Sunflower *Helianthus spp.*		14.1/47.4	27.4/63.0	21.5/37.5	21.1/42.3	4.3/25.7	1.9/18.7	0.1/3.2	0.0/0.0	13.9/36.9
Western Ragweed *Ambrosia artemisiifolia and A. psilostachya*		1.1/19.7	12.4/53.6	10.2/49.0	11.3/36.5	2.5/17.1	0.1/4.7	0.1/1.6	0.0/0.0	7.1/20.9
Sumac *Rhus glabra and R. aromatica*		0.1/1.3	0.1/3.6	0.6/7.5	5.3/14.1	11.6/23.7	23.7/25.0	4.0/12.7	14.3/11.6	6.4/12.0
Corn *Zea mays*		0.0/0.0	0.0/0.0	0.4/1.9	0.7/2.4	6.1/14.3	7.8/10.9	31.5/22.2	25.6/25.6	5.4/7.8
Oak (Acorn Meat) *Quercus spp.*		0.0/0.0	4.0/7.1	10.1/9.4	2.3/4.7	2.6/4.3	2.4/3.1	8.4/7.9	0.0/0.0	4.2/5.1
Giant Ragweed *Ambrosia trifida*		0.5/7.9	0.4/6.0	5.4/21.7	5.4/21.7	3.0/15.7	0.6/6.2	0.9/9.5	0.7/4.7	2.6/13.2
Osage orange *Maclura pomifera*		0.0/0.0	0.0/0.0	0.0/0.9	2.6/5.9	3.5/8.6	2.5/9.4	13.1/9.5	0.4/2.3	2.3/4.2
Dogwood *Cornus drummondi*		4.8/19.7	1.0/3.6	1.7/13.2	2.2/4.7	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0	2.0/6.1
Woolly Croton *Croton capitatus*		0.7/10.5	2.5/8.3	0.4/3.8	6.2/10.6	0.5/1.4	0.3/3.1	5.1/4.5	0.0/0.0	2.0/5.8
Black Locust *Robinia pseudo-acacia*		0.0/0.0	0.1/1.2	0.0/0.0	1.0/3.5	3.5/7.1	3.7/4.7	7.9/12.7	3.0/4.7	1.9/3.7
American Germandar *Teucrium canadense*		1.9/18.4	1.3/9.5	1.3/11.3	3.6/22.3	2.6/3.7	0.0/0.0	2.0/3.2	0.0/0.0	1.8/10.0
Common Wheat *Triticum aestivum*		3.4/5.3	0.4/2.4	0.0/0.0	3.9/5.9	1.7/2.9	2.6/3.1	0.0/0.0	0.0/0.0	1.7/2.5
Partridgepea *Chamaecrista nictitans*		0.2/6.6	0.9/4.8	0.2/3.8	0.3/3.5	8.1/14.3	0.0/0.0	0.7/3.2	0.1/2.3	1.5/4.9
Hemp *Cannabis sativa*		0.2/2.0	4.1/11.9	0.2/3.8	0.4/3.5	3.7/5.7	0.0/1.6	0.2/1.6	0.1/2.3	1.3/4.4
Smartweed *Polygonum scandens*		0.1/2.6	0.8/8.3	1.1/8.5	3.4/10.5	0.4/5.7	1.5/4.7	1.8/7.9	0.1/2.3	1.2/7.6
Riverbank Grape *Vitis vulpina*		0.0/0.0	0.3/1.2	3.2/4.7	2.4/3.5	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0	1.0/1.5
Grasses (Native)		38.0/69.8	13.8/59.5	5.5/29.2	5.3/20.0	0.8/11.4	5.5/12.5	4.3/7.9	1.7/7.0	9.7/29.6
Animal Matter		17.6/65.8	13.3/52.4	0.0/31.1	0.7/12.9	2.5/17.1	0.7/7.8	2.1/14.3	17.4/32.6	7.5/27.8
Debris		0.4/6.6	0.7/6.0	0.2/.9	1.4/5.9	5.0/20.0	4.6/17.2	4.6/6.3	3.7/16.3	2.2/9.0

also reported adult bobwhite quail outweighed juveniles during winter months.

Quail weight changes observed could reflect changes in net energy balances. In general, an animal gains weight when it consumes energy in excess of its requirements and loses weight if energy intake is below its requirements. Zimmerman's data (Personal communication) predicts an *existence energy* requirement of approximately 0.38 kcal/gm/day for birds held in an environment of 0 C and 9- to 12-hour photoperiod. Existence energy is that required for normal activity of a specimen in a confined area. *Productive energy* is that in excess of the existence requirement (Zimmerman 1965:382–383) and is the energy available for daily movements, foraging for food, fat accumulation, etc.

The following energy–weight relationship discussion is based on three premises: (1) the average crop contents (Table 4) is a true representation of the average crop contents for the entire daily feeding period; (2) the crop contents are passed through the alimentary tract of bobwhite quail every 1.5 hours, a rate reported for coturnix quail (*Coturnix coturnix*) by McFarland and Freedland (1965); and (3) the average daily feeding period extends from sunrise to 30 minutes after sunset. Based on studies by Robel and Harper (1965) and Johnson (1968), the average diet (Table 5) of a bobwhite on the Fort Riley Military Reservation contains approximately 2.30 kcal/cc. By multiplying the average crop contents by the number of 1.5-hour feeding units in the daily feeding period, it is possible to estimate the total daily food intake. Daily energy consumption is estimated by multiplying the daily food intake (cc) by 2.30

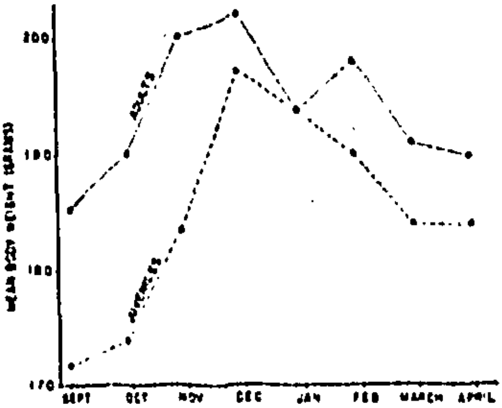

Fig. 2. Mean weights of 284 juvenile and 84 adult bobwhite quail collected during September–April.

Table 6. Mean body weights by months of 284 juvenile and 84 adult bobwhite quail collected during this study.

Month	Juveniles		Adults		Pooled	
	N	Mean Weight[a]	N	Mean Weight	N	Mean Weight
September	42	171.08 ± 3.13	4	185.13 ± 9.06	46	172.85 ± 3.00
October	45	173.98 ± 3.49	8	189.85 ± 3.28[c]	53	176.38 ± 3.10
November	38	183.27 ± 3.05	9	200.31 ± 2.02[c]	47	186.33 ± 3.13
December	27	197.14 ± 2.54	13	201.28 ± 4.00	40	198.81 ± 2.10
January	36	193.90 ± 3.90	11	193.85 ± 4.56	47	193.89 ± 3.13
February	36	190.01 ± 2.79	15	198.26 ± 4.03	51	192.44 ± 2.34
March	34	183.86 ± 1.80	9	191.10 ± 3.30[b]	43	185.37 ± 1.64
April	26	184.05 ± 2.09	15	189.99 ± 4.98	41	186.22 ± 2.03

[a] Weights in grams ± one standard error of the mean.
[b] Significantly greater ($P < 0.10$) than the weight of juveniles collected during the same month.
[c] Significantly greater ($P < 0.05$) than the weight of juveniles collected during the same month.

Table 7. Estimated daily food and energy consumption by bobwhite quail during the September–April period on the study area.

Month	Feeding Period* (hr/day)	Feeding Units (1.5-hr duration)	Average Crop Contents (cc)		Daily Food Consumption (cc)		Daily Energy Consumption (kcal)	
			Juv.	Adults	Juv.	Adults	Juv.	Adults
September	12.98	8.65	5.57	6.17	48.18	53.37	110.81	122.75
October	11.72	7.81	6.01	5.78	46.94	45.14	107.96	103.82
November	10.55	7.03	6.03	9.37	42.39	65.87	97.50	151.50
December	9.92	6.61	6.25	8.70	41.31	57.51	95.01	132.27
January	10.22	6.81	8.10	6.58	55.16	44.81	126.87	103.06
February	11.23	7.49	6.37	6.58	47.71	49.28	109.73	113.34
March	12.40	8.27	4.03	5.00	33.33	41.35	76.66	95.11
April	13.72	9.15	2.07	4.87	18.94	44.56	43.56	102.49

* Average daylight hours; sunrise to ½ hr after sunset.

(kcal/cc) (Table 7). Birds normally are able to assimilate about 70 percent of the ingested energy when the environmental temperature is 0 C to 10 C (Zimmerman 1965:380).

The existence energy requirement for a 173-g quail (mean weight of 46 birds collected in September) is 66 kcal/day, an amount supplied by 94 kcal/day of food intake. The mean energy consumption by 343 quail during September–December was 106 kcal/day, a diet providing at least 12-kcal of productive energy per day. The 12-kcal/day productive energy figure is probably conservative since the 94 kcal/day existence energy requirement is based on a 0 C temperature mean and the mean temperature on our study area was approximately 11 C for the September–December period. The existence energy requirement for a 200-g quail (mean weight of 40 birds collected in December) is 76 kcal/day, an amount supplied by 109 kcal/day of food consumed. The mean energy consumption by 240 quail during January–April was 98 kcal/day, a diet providing –11 kcal of productive energy per day. The –11 kcal/day deficit is a fairly close estimate since the mean temperature for the period was 3.2 C, not significantly higher than 0 C on which Zimmerman's calculations were based. Generally, when energy intake exceeded energy requirements (positive energy balance), quail gained weight and when energy intake was less than that required (negative energy balance), quail lost weight. The greater negative energy balance of the juveniles (–13 and –5 kcal/day for juveniles and adults, respectively) might account for the greater weight loss by juveniles during January–April (Fig. 2). Even though much more research is needed on quail bioenergetics to refine the above weight-energy relationship, the hypothesis offers a partial (though tentative) explanation for loss of weight by bobwhite during late winter and early spring.

By no means is it inferred that there is a simple direct relationship between energy intake and weight changes in bobwhite quail. Several abiotic (photoperiod, temperature, chemical, etc.) and biotic (behavioral and internal regulatory processes) factors have been shown to be related to basic energy metabolism (Kirkpatrick 1957, King and Farner 1959, 1961, and 1963). Thus, it seems that energy intake is only one (admittedly a major one) of several inter-related factors associated with body weight changes in unconfined bobwhite quail.

Content of ether-extractable fat (expressed as percentage of total dry tissue weight) in the carcasses of 41 quail showed little seasonal variation, although birds collected in September had less ($P < 0.01$) fat than birds collected in November, January, and March. The carcasses of 10 bobwhites collected during September consisted of 9.15 ± 0.55 percent fat while the carcasses of 11 birds collected in November contained 13.86 ± 0.79 percent fat. Carcasses of 10 bobwhites collected in January averaged 13.74 ± 1.86 percent fat while 10 birds collected in March averaged 12.18 ± 1.00 percent fat. The highest fat content (28.46 percent of dry body weight) was found in a juvenile female collected during January and the least amount of fat (4.21 percent of dry body weight) was found in a juvenile female also collected in January. The bird with the highest fat content was killed in a food plot while the one with the least amount of fat was killed about 1,200 m from a food plot. The number of birds analyzed for fat content was not large enough to detect age or sex-related differences in fat content.

Effectiveness of Food Plots

Sorghum and corn produced on food plots comprised 18.3 and 5.4 percent, respectively, of the total contents of 591 quail crops analyzed (Table 5). Wheat contributed only 1.7 percent of the total diet. Corn was utilized by bobwhites principally in January–April, whereas wheat was consumed sporadically throughout September–April. Sorghum was utilized throughout September–April, but more extensively in January–April. Except for riverbank grape, wheat was the least commonly occurring food item which constituted 1.0 percent or more of the total volumetric contents.

Of 120 quail killed within 300 m of a food plot during January–April, 83 (69.2 percent) had grain in their crop (Table 8). No bird killed farther than 900 m from a food plot during January–April contained grain in its crop. Of all birds having grain in their crops during January–April, 96.1 percent were collected within 600 m of a food plot.

Table 8. Presence of cultivated grain in crops of 221 quail collected at varying distances from food plots during January–April.

Distance Class (meters)	N	With Grain N	With Grain Percent	Percent of 101 Crops Containing Grain*
0–299	120	83	69.2	82.2
300–599	42	14	33.3	13.9
600–899	17	4	23.5	3.9
900+	42	0	0.0	0.0
	221	101	45.7	100.0

Since food plots appear to be a major source of food for quail within a 600-m radius during January–April, crop contents, body weight, and body fat content of birds collected within this radius were compared with similar data of birds collected farther from food plots. Because birds collected 600–900 m from food plots occasionally utilized the food plots as a food source, they were omitted from the comparison, and birds collected within 600 m of a food plot were compared with birds collected 900 m or farther from a food plot.

On the whole, birds killed within 600 m of a food plot weighed more than birds killed farther than 900 m from a food plot, 190.79 and 187.56 g, respectively. Only during February was the mean weight of quail in the 900-m and over category greater than that of birds killed within 600 m of a food plot (Table 9). Mean weights of birds killed within 600 m of a food plot were significantly greater than birds killed over 900 m from a food plot in January ($P < 0.01$) and April ($P < 0.05$). Although a similar trend was evident for the volume of food in the crops of quail, that is, birds in the 0- to 600-m category having more food in their crops than did birds in the 900-m and

Table 9. Comparison of crop contents and body weights of birds killed within 600 m of a food plot with similar data for birds collected over 900 m from a food plot

Distance Class (m)	January N	January Volume[a]	February N	February Volume	March N	March Volume	April N	April Volume
				Volumetric Content (cc)				
0 to 600	30	8.30 ± 0.70	39	6.48 ± 0.61	32	4.70 ± 0.68	28	3.59 ± 0.72
900+	15	7.23 ± 0.98	9	6.14 ± 1.27	5	3.18 ± 1.71	9	2.06 ± 1.27

Distance Class (m)	January N	January Weight	February N	February Weight	March N	March Weight	April N	April Weight
				Body Weight (g)				
0 to 600	30	196.77 ± 1.07**	39	191.89 ± 1.47	32	186.14 ± 1.62	28	188.20 ± 1.73*
900+	15	189.80 ± 2.30	9	191.04 ± 3.05	5	186.00 ± 4.88	9	180.93 ± 3.03

[a] All measurements are means ± standard error.
* Significantly greater ($P < 0.05$) than mean of other distance class.
** Significantly greater ($P < 0.01$) than mean of other distance class.

over category (arithmetic means of 5.78 and 4.65 g, respectively), none of the monthly differences was significant (Table 9).

Since age and month plus distance from food plots appeared to be related to body weight and volume of food in the crop of the bird (Tables 4, 6, 7, and 9), a more thorough analysis of the data was undertaken to detect the effects of all of these factors during late winter and early spring. Of the 251 bobwhite quail collected during January–April, complete data (sex, age, weight, and crop contents) were available for 129 and 38 birds in the 0–600 and over 900 m-distance classes, respectively.

An analysis of variance by the least square method was used to determine the more important factors in the variations of body weight and crop contents of the birds collected in different months and distance classes. Significant relationships ($P < 0.01$) were detected between body weight and months and body weight and age. For quail body weight, the month–distance and month–age interactions were also significant ($P < 0.05$) as well as the distance–age interaction ($P < 0.01$). None of the other factors or combinations of factors (distance, sex, month–sex, distance–sex, or age–sex) was significantly related to changes in quail body weight (Table 10). Of the four variables tested (month, distance, age, and sex), only month was significantly ($P < 0.01$) related to the volume of food in the quail's crop. None of the interactions between these factors was significant (Table 12).

Least square estimates of the effects of each significant factor and factor-interactions related to quail body weight are presented in Table 11. Mean body weight

Table 10. Results of analysis of variance of weight data for 167 bobwhite quail collected during winter and early spring.

Factors	Degrees of Freedom	Mean Square	F Value
Month[a]	3	489.92	5.85**
Distance[b]	1	2.11	0.03
Sex	1	65.00	0.78
Age	1	1978.96	23.62**
Month × Distance	3	225.57	2.69*
Month × Sex	3	115.06	1.37
Month × Age	3	260.43	3.11*
Distance × Sex	1	112.00	1.34
Distance × Age	1	861.51	10.28**
Sex × Age	1	70.20	0.84
Error	*160*	83.78	

[a] Month factor = January, February, March, and April.
[b] *Distance factor = 0 to 600, and over 900 m from a* food plot.
* Statistically significant ($P < 0.05$).
** Statistically significant ($P < 0.01$).

Table 11. Summary of least square estimates for each significant factor and factor-interaction listed in Table 10.

	MONTH ONLY	MONTH-AGE INTERACTION		MONTH-DISTANCE INTERACTION	
		Juveniles	Adults	0–600 m	900+ m
January	1.06[a]	4.21	−4.21	2.06	−2.06
February	0.00	−1.67	1.67	−3.92	3.92
March	−3.59	−1.98	1.98	0.80	−0.80
April	−3.46	−0.55	0.55	1.06	−1.06

	AGE ONLY	AGE-DISTANCE INTERACTION	
		0–600 Meters	900+ Meters
Juveniles	−4.84	3.26	−3.26
Adults	4.84	−3.26	3.26

[a] Estimates in grams; overall mean weight (least square estimate) of the 167 bobwhite quail is 190.86 g.

(least square estimate) for the 167 quail was 190.86 grams. Figures appearing in Table 11 should be added to this mean weight to determine the actual quail weights, that is, considering the effects of month only, the mean weight of the 167 quail is estimated to be 191.91, 190.86, 187.26, and 187.39 g for the months of January, February, March, and April, respectively. By combining the effects of significant factors, a quail killed over 900 m from a food plot in January would have an estimated weight of 189.85 g (190.86 + 1.06 − 2.06), very close to the actual mean of 189.86 g for 15 birds in that category (Table 9). For birds killed within 600 m of a food plot in April, the estimated mean weight would be 188.45 g while the actual mean for 28 birds in that category was 188.20 g (Table 9). Least square estimates for the effects of month on volume of food in the crops of quail were 1.66, 1.46, −1.04, and −2.08 for January, February, March, and April, respectively. Mean crop content (least square estimate) for the 167 quail was 5.33 cc. Estimated mean crop contents of birds killed in March would be 4.29 cc, fairly close to the actual mean of 4.20 cc for 63 birds killed during that month (Table 4).

An analysis of variance (least square method) of fat content data of birds collected within 600 m of a food plot compared to those collected over 900 m from a food plot detected slight interactions between sex, age, distance, and month, but none was significant. A two-way analysis of variance detected a significant ($P < 0.05$) relationship between distance and fat content, substantiating data presented in Table 13. Birds killed within 600 m of a food plot had more fat ($P < 0.05$) in their bodies during January and March than did birds killed 900 or more m from a food plot during the same months. Seven of the 20 quail

Table 12. Results of an analysis of variance of volume of crop contents of 167 bobwhite quail collected during winter and early spring.

FACTORS	DEGREES OF FREEDOM	MEAN SQUARE	F VALUE
Month[a]	3	88.77	6.10**
Distance[b]	1	8.30	0.57
Sex	1	15.54	1.07
Age	1	12.51	0.86
Month × Distance	3	1.80	0.12
Month × Sex	3	0.51	0.05
Month × Age	3	25.31	1.74
Distance × Sex	1	1.21	0.09
Distance × Age	1	0.00	0.00
Sex × Age	1	1.37	0.94
Error	166	14.56	

[a] Month factor = January, February, March, and April.
[b] Distance factor = 0 to 600, and over 900 m from a food plot.
** Statistically significant ($P < 0.01$).

Table 11. Content of ether extractable fat in carcasses of bobwhite quail collected within 600 m of a food plot compared with fat content of birds collected farther than 900 m from a food plot.

Distance Class	September		November		January		March	
	N	Percent Fat	N	Percent Fat	N	Percent Fat	N	Percent Fat
0–599	9	9.53 ± 0.52[a]	3	15.24 ± 1.55	6	17.10 ± 2.40[c]	5	13.98 ± 1.14[c]
900+	1	5.81[b]	7	13.74 ± 0.80	4	8.71 ± 2.91	3	9.35 ± 3.40

[a] Percent fat (dry basis) ± one standard error of the mean.
[b] No standard error calculated.
[c] Significantly greater ($P < 0.05$) than comparable figure for other distance class.

killed and analyzed for fat during January and March had over 14 percent fat in their bodies; 6 of these 7 (86 percent) were killed within 600 m of a food plot.

Therefore, during the winter and early spring, food plots established for bobwhite quail on the Fort Riley Military Reservation appear to have been successful in (1) increasing energy intake, (2) maintaining higher body weight, and (3) maintaining a higher fat content in the body of bobwhite quail. Although the survival value of these three effects has not been established in unconfined bobwhite quail populations, the results obtained to date certainly seem encouraging and justify continuation of this phase of the habitat-improvement program on the Reservation.

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